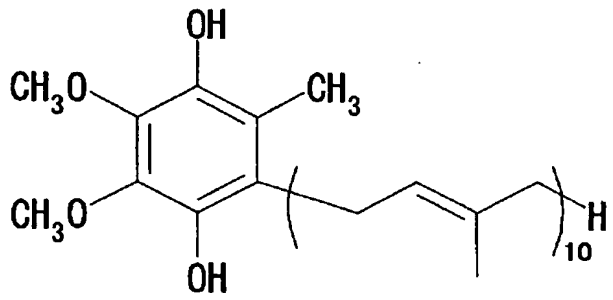
CLAIMS

1. A process for producing the reduced coenzyme Q_{10} represented by the following formula (I):



(I)

which comprises culturing reduced coenzyme Q_{10}-producing microorganisms in a culture medium containing a carbon source, a nitrogen source, a phosphorus source and a micronutrient to obtain microbial cells containing reduced coenzyme Q_{10} at a ratio of not less than 70 mole % among the entire coenzymes Q_{10},

optionally disrupting the microbial cells and

extracting thus-produced reduced coenzyme Q_{10} by an organic solvent.

2. The process according to Claim 1,

wherein the reduced coenzyme Q_{10} is contained at a ratio of not less than 70 mole % among the entire coenzymes Q_{10}.

3. The process according to Claim 1 or 2,

wherein the production amount of reduced coenzyme Q_{10} on completion of the culture is not less than 1 μg/mL.

4. The process according to any one of Claims 1 to 3,

wherein the culture is carried out at 15 to 45°C and at a pH of 4 to 9.

5. The process according to any one of Claims 1 to 4,

wherein the concentration of the carbon source in the culture is controlled to a concentration that no adverse effects are substantially caused on the productivity of reduced coenzyme Q_{10}.

6. The process according to Claim 5,
wherein the culture is carried out by a fed batch culture method.

7. The process according to Claim 6,
wherein the carbon source is supplied to the culture medium separately from other components.

8. The process according to any one of Claims 1 to 7,
wherein the culture is carried out aerobically.

9. The process according to any one of Claims 1 to 8,
wherein the microbial cells are disrupted in the extraction.

10. The process according to Claim 9,
wherein the cell disruption is carried out by a physical treatment, a chemical treatment, an enzymic treatment, a heating treatment, an autolysis, an osmolysis or a plasmoptysis.

11. The process according to Claim 9,
wherein the cell disruption is carried out by a physical treatment, an acid treatment with a strong acid or a heating treatment.

12. The process according to Claim 9,
wherein the cell disruption is carried out by a physical treatment.

13. The process according to Claim 12,
wherein the physical treatment is carried out by a high pressure homogenizer, an ultrasonic homogenizer, a French press or a ball mill.

14. The process according to any one of Claims 9 to 13,
wherein the cell disruption is carried out under an acidic to a weakly basic condition.

15. The process according to any one of Claims 1 to 14,
wherein, as the organic solvent to be used for extraction of reduced coenzyme Q_{10}, at least one species of hydrocarbons, fatty acid esters, ethers and nitriles is used.

16. The process according to any one of Claims 1 to 14,
wherein the extraction of reduced coenzymes Q_{10} is carried out from wet cells or dry cells of the microbial cells or disrupted product thereof by using a hydrophilic organic solvent.

17. The process according to Claim 16,
wherein the hydrophilic organic solvent is acetone, acetonitrile, methanol, ethanol, 1-propanol or 2-propanol.

18. The process according to any one of Claims 1 to 15,
wherein the extraction of the reduced coenzymes Q_{10} is carried out from an aqueous suspension of the microbial cells or disrupted product thereof by using a hydrophobic organic solvent.

19. The process according to Claim 18, wherein the hydrophobic organic solvent is a hydrocarbon, a fatty acid ester or an ether.

20. The process according to Claim 18 or 19, wherein the hydrophilic organic solvent is used as an auxiliary solvent in combination with the hydrophobic organic solvent.

21. The process according to Claim 20, wherein the hydrophobic organic solvent is a hydrocarbon, and the hydrophilic organic solvent is an alcohol.

22. The process according to Claim 20, wherein the hydrophobic organic solvent is an aliphatic hydrocarbon, and the hydrophilic organic solvent is a monohydric alcohol containing 1 to 5 carbon atoms.

23. The process according to Claim 20, wherein the hydrophobic organic solvent is at least one species of hexane and heptane, and the hydrophilic organic solvent is at least one species of methanol, ethanol, 1-propanol and 2-propanol.

24. The process according to any one of Claims 20 to 23, wherein the extraction is carried out under the condition that the hydrophobic organic solvent is contained in 25 to 65% by volume and the hydrophilic organic solvent is contained in 5 to 50% by volume.

25. The process according to any one of Claims 18 to 24, wherein the extraction is carried out by continuous

extraction.

26. The process according to any one of Claims 1 to 25,

wherein the extraction is carried out under an acidic to a weakly basic condition.

27. The process according to any one of Claims 1 to 26,

wherein the cell disruption and/or extraction is carried out under the condition that the reduced coenzyme Q_{10} is protected from an oxidation reaction.

28. The process according to Claim 27,

wherein the condition that the reduced coenzyme Q_{10} is protected from an oxidation reaction is a deoxygenized atmosphere, a high salt concentration condition, the condition in the presence of a strong acid, the condition in the presence of an antioxidant, or a reduction condition.

29. The process according to any one of Claims 1 to 28,

wherein the reduced coenzyme Q_{10} is contained at a ratio of not less than 70 mole % among the entire coenzymes Q_{10}

in the case that the reduced coenzyme Q_{10}-producing microorganisms are cultured with shaking (amplitude: 2 cm, 310 reciprocation/min) at 25°C for 72 hours in 10 mL of a culture medium [(glucose: 20 g, peptone: 5 g, yeast extract: 3g, malt extract: 3 g)/L, pH: 6.0] using a test tube (inner diameter: 21 mm, entire length: 200 mm),

the obtained broth is optionally concentrated,

the obtained solution is vigorously shaken for 3 minutes using 10 parts by volume of glass beads (425 to 600 μm) to disrupt the microorganisms under a nitrogen

atmosphere in the concomitant presence of 3 parts by volume of isopropanol and 18.5 parts by volume of n-hexane relative to 10 parts by volume of the broth, and

the prepared hydrophobic organic solvent phase (n-hexane phase) is analyzed by HPLC.

30. The process according to Claim 29,

wherein the reduced coenzyme Q_{10}-producing microorganisms have not less than 1 μg/mL of a productivity of reduced coenzyme Q_{10} per unit culture medium when measured by HPLC under the condition according to Claim 29.

31. The process according to any one of Claims 1 to 30,

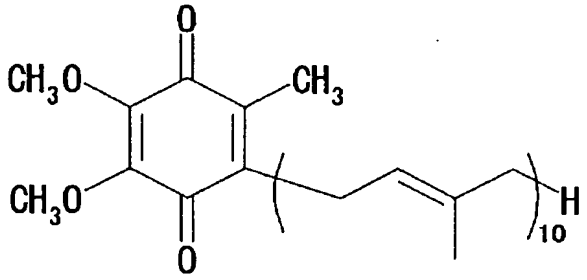
wherein the microorganisms are microorganisms of the genus Agrobacterium, the genus Aspergillus, the genus Acetobacter, the genus Aminobacter, the genus Agromonas, the genus Acidiphilium, the genus Bulleromyces, the genus Bullera, the genus Brevundimonas, the genus Cryptococcus, the genus Chionosphaera, the genus Candida, the genus Cerinosterus, the genus Exisophiala, the genus Exobasidium, the genus Fellomyces, the genus Filobasidiella, the genus Filobasidium, the genus Geotrichum, the genus Graphiola, the genus Gluconobacter, the genus Kockovaella, the genus Kurtzmanomyces, the genus Lalaria, the genus Leucosporidium, the genus Legionella, the genus Methylobacterium, the genus Mycoplana, the genus Oosporidium, the genus Pseudomonas, the genus Psedozyma, the genus Paracoccus, the genus Petromyc, the genus Rhodotorula, the genus Rhodosporidium, the genus Rhizomonas, the genus Rhodobium, the genus Rhodoplanes, the genus Rhodopseudomonas, the genus Rhodobacter, the genus Sporobolomyces, the genus Sporidiobolus, the genus Saitoella, the genus Schizosaccharomyces, the genus Sphingomonas, the genus Sporotrichum, the genus Sympodiomycopsis, the genus

Sterigmatosporidium, the genus Tapharina, the genus Tremella, the genus Trichosporon, the genus Tilletiaria, the genus Tilletia, the genus Tolyposporium, the genus Tilletiopsis, the genus Ustilago, the genus Udeniomyce, the genus Xanthophllomyces, the genus Xanthobacter, the genus Paecilomyces, the genus Acremonium, the genus Hyhomonus, or the genus Rhizobium.

32. The process according to any one of Claims 1 to 31,

wherein the obtained reduced coenzyme Q_{10} is purified optionally and crystallized to obtain a reduced coenzyme Q_{10} crystal.

33. A process for producing the oxidized coenzyme Q_{10} represented by the following formula (II):



(II)

which comprises culturing reduced coenzyme Q_{10}-producing microorganisms in a culture medium containing a carbon source, a nitrogen source, a phosphorus source and a micronutrient to obtain microbial cells containing reduced coenzyme Q_{10} at a ratio of not less than 70 mole % among the entire coenzymes Q_{10},

optionally disrupting the microbial cells; and

either oxidizing thus-produced reduced coenzyme Q_{10} to oxidized coenzyme Q_{10} and then extracting the resultant by an organic solvent, or extracting thus-produced reduced coenzyme Q_{10} by an organic solvent, purifying optionally and oxidizing the resultant to oxidized coenzyme Q_{10}.

34. The process according to Claim 33,
wherein the production amount of reduced coenzyme Q_{10} on completion of the culture is not less than 1 μg/mL.

35. The process according to Claim 33 or 34,
wherein the culture is carried out at 15 to 45°C and at a pH of 4 to 9.

36. The process according to any one of Claims 33 to 35,
wherein the concentration of the carbon source in the culture is controlled to a concentration that no adverse effects are substantially caused on the productivity of reduced coenzyme Q_{10}.

37. The process according to Claim 36,
wherein the culture is carried out by a fed batch culture method.

38. The process according to Claim 37,
wherein the carbon source is supplied to the culture medium separately from other components.

39. The process according to any one of Claims 33 to 38,
wherein the culture is carried out aerobically.

40. The process according to any one of Claims 33 to 39,
wherein the microbial cells are disrupted in the extraction.

41. The process according to Claim 40,
wherein the cell disruption is carried out by a

physical treatment, a chemical treatment, an enzymic treatment, a heating treatment, an autolysis, an osmolysis or a plasmoptysis.

42. The process according to Claim 41,
wherein the cell disruption is carried out by a physical treatment.

43. The process according to Claim 42,
wherein the physical treatment is carried out by a high pressure homogenizer, an ultrasonic homogenizer, a French press or a ball mill.

44. The process according to any one of Claims 33 to 43,
wherein the extraction of coenzymes Q_{10} is carried out from wet cells or dry cells of the microbial cells or disrupted product thereof by using a hydrophilic organic solvent.

45. The process according to Claim 44,
wherein the hydrophilic organic solvent is acetone, acetonitrile, methanol, ethanol, 1-propanol or 2-propanol.

46. The process according to any one of Claims 33 to 43,
wherein the extraction of the coenzymes Q_{10} is carried out from an aqueous suspension of the microbial cells or disrupted product thereof by using a hydrophobic organic solvent.

47. The process according to Claim 46,
wherein the hydrophobic organic solvent is a hydrocarbon, a fatty acid ester or an ether.

48. The process according to Claim 46 or 47,

wherein the hydrophilic organic solvent is used as an auxiliary solvent in combination with the hydrophobic organic solvent.

49. The process according to Claim 48,

wherein the hydrophobic organic solvent is a hydrocarbon, and the hydrophilic organic solvent is an alcohol.

50. The process according to Claim 48,

wherein the hydrophobic organic solvent is an aliphatic hydrocarbon, and the hydrophilic organic solvent is a monohydric alcohol containing 1 to 5 carbon atoms.

51. The process according to Claim 48,

wherein the hydrophobic organic solvent is at least one species of hexane and heptane, and the hydrophilic organic solvent is at least one species of methanol, ethanol, 1-propanol and 2-propanol.

52. The process according to any one of Claims 48 to 51,

wherein the extraction is carried out under the condition that the hydrophobic organic solvent is contained in 25 to 65% by volume and the hydrophilic organic solvent is contained in 5 to 50% by volume.

53. The process according to any one of Claims 46 to 52,

wherein the extraction is carried out by continuous extraction.

54. The process according to any one of Claims 33 to 53,

wherein the reduced coenzyme Q_{10} is contained at a ratio of not less than 70 mole % among the entire coenzymes Q_{10}

in the case that the reduced coenzyme Q_{10}-producing microorganisms are cultured with shaking (amplitude: 2 cm, 310 reciprocation/min) at 25°C for 72 hours in 10 mL of a culture medium [(glucose: 20 g, peptone: 5 g, yeast extract: 3g, malt extract: 3 g)/L, pH: 6.0] using a test tube (inner diameter: 21 mm, entire length: 200 mm),

the obtained broth is optionally concentrated,

the obtained solution is vigorously shaken for 3 minutes using 10 parts by volume of glass beads (425 to 600 μm) to disrupt the microorganisms under a nitrogen atmosphere in the concomitant presence of 3 parts by volume of isopropanol and 18.5 parts by volume of n-hexane relative to 10 parts by volume of the broth, and

the prepared hydrophobic organic solvent phase (n-hexane phase) is analyzed by HPLC.

55. The process according to Claim 54,

wherein the reduced coenzyme Q_{10}-producing microorganisms have not less than 1 μg/mL of a productivity of reduced coenzyme Q_{10} per unit culture medium when measured by HPLC under the condition according to Claim 54.

56. The process according to any one of Claims 33 to 55,

wherein the microorganisms are microorganisms of the genus Agrobacterium, the genus Aspergillus, the genus Acetobacter, the genus Aminobacter, the genus Agromonas, the genus Acidiphilium, the genus Bulleromyces, the genus Bullera, the genus Brevundimonas, the genus Cryptococcus, the genus Chionosphaera, the genus Candida, the genus Cerinosterus, the genus Exisophiala, the genus Exobasidium, the genus Fellomyces, the genus Filobasidiella, the genus

Filobasidium, the genus Geotrichum, the genus Graphiola, the genus Gluconobacter, the genus Kockovaella, the genus Kurtzmanomyces, the genus Lalaria, the genus Leucosporidium, the genus Legionella, the genus Methylobacterium, the genus Mycoplana, the genus Oosporidium, the genus Pseudomonas, the genus Psedozyma, the genus Paracoccus, the genus Petromyc, the genus Rhodotorula, the genus Rhodosporidium, the genus Rhizomonas, the genus Rhodobium, the genus Rhodoplanes, the genus Rhodopseudomonas, the genus Rhodobacter, the genus Sporobolomyces, the genus Sporidiobolus, the genus Saitoella, the genus Schizosaccharomyces, the genus Sphingomonas, the genus Sporotrichum, the genus Sympodiomycopsis, the genus Sterigmatosporidium, the genus Tapharina, the genus Tremella, the genus Trichosporon, the genus Tilletiaria, the genus Tilletia, the genus Tolyposporium, the genus Tilletiopsis, the genus Ustilago, the genus Udeniomyce, the genus Xanthophllomyces, the genus Xanthobacter, the genus Paecilomyces, the genus Acremonium, the genus Hyhomonus, or the genus Rhizobium.

57. The process according to any one of Claims 33 to 56,

wherein the obtained oxidized coenzyme Q_{10} is purified optionally and crystallized to obtain an oxidized coenzyme Q_{10} crystal.